

APPLICATION UNDER UNITED STATES PATENT LAWS

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Invention: REMOTE MACHINE VISION SERVER

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This is a:

- ☐ Provisional Application
- ☐ Regular Utility Application
- ☒ Continuing Application
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SPECIFICATION

Remote Machine Vision Server

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BACKGROUND OF THE INVENTION

1. Copyright Notice.

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15 2. Field of the Invention.

Aspects of the present invention generally relate to machine vision. Other, aspects of the present invention relate to providing access to the results of machine vision operations.

3. Description of Background Information.

Machine vision technology is used around the world to automatically gauge part dimensions, guide robotic equipment, identify products, and inspect for defects in industries that include, but are not limited to, semiconductors, electronics, automotive parts, consumer products, electrical components, medical devices, and packaging. Figure 2, for example, illustrates a machine vision system 200 in which an image acquisition subsystem 202, positioned on a production line, captures and stores an image of the part to be inspected. A machine vision computer 204 then uses machine vision image and data analysis software to extract information from the image and to produce a result that can be used to make decisions about the image. Once the vision system has processed and analyzed the image, the result

206 is communicated to the operator, or, as illustrated, to other manufacturing equipment 208 on the factory floor. The result may be used to control manufacturing equipment or to determine the quality of a part, or it may be input to another image analysis operation.

The machine vision software on computer 204 performs image analysis operations.

- 5 Examples of image analysis operations include, but are not limited to, pattern location algorithms, gauging algorithms, character recognition algorithms, and image filters such as a Gaussian filter.

Suppliers of machine vision software may protect their software from unauthorized duplication by using a hardware or software security method. In addition, or as a substitute
10 for hardware or software security methods, users of machine vision may be forced to support awkward licensing schemes imposed by machine vision vendors in an effort to protect their software from unauthorized use or duplication. Depending on the type of security used, licensees may be required to pay for licenses not needed to support their usage.

In addition, machine vision systems are difficult to maintain in the field. For instance,
15 it may be challenging to update a machine vision system with a new version of software, or a new license, after it has been installed on a manufacturing production line. Moreover, customers wishing to test proprietary machine vision software on a particular part may be required to purchase and install software and the associated licenses, which is a significant deterrent to "quick-turn" software development.

20 To be more specific vendors may use one of the following three security methods to prevent improper copying or use of their software:

- Hardware security, for example, a security code may be programmed into a hardware device, such as EEPROM on a frame grabber, or a hardware dongle which plugs into a

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is further described in the detailed description which follows, by reference to the noted drawings by way of non-limiting exemplary embodiments, in which like reference numerals represent similar parts throughout the several views of the drawings, and wherein:

FIGURE 1 is an illustrative diagram of an exemplary visual inspection system that can be employed by, for example, a machine vision system for inspecting at least one characteristic of a material, such as a continuous web product having a generally uniform structure, using a set of optical arrangements in an inspection process in accordance with the exemplary embodiment of the invention;

FIGURE 2 is a flow chart illustrating a method designed in accordance with a first exemplary embodiment of the invention in which a material, such as a continuous web product or material, is inspected for at least one characteristic of the material using a set of optical arrangements;

FIGURE 3 is a flow chart showing the method of FIGURE 2 in greater detail;

FIGURE 4 is a flow chart illustrating a method designed in accordance with a second exemplary embodiment of the invention in which a material, such as a continuous web product or material, is inspected for at least one characteristic of the material using a set of optical arrangements;

FIGURE 5 is a flow chart showing the method of FIGURE 4 in greater detail;

FIGURE 6 is a flow chart showing the method of FIGURE 5 in greater detail;

FIGURE 7 is an illustrative diagram of the elements of the visual inspection system illustrated in FIGURE 1; and

FIGURE 8 is an illustrative diagram showing a modification of the visual inspection system illustrated in FIGURE 7.

DETAILED DESCRIPTION

Referring to FIGURE 1, in accordance with the present invention, there is provided a visual inspection system that can be employed by, for example, a machine vision system for inspecting at least one characteristic of a material using a set of optical arrangements in an inspection process such as commonly occur in automated manufacturing. For example, the visual inspection system can be employed in a machine vision system 10 for a manufacturing line such as a manufacturing line 12, as shown in FIGURE 1.

Using the inspection system, sample-object 14, e.g., a continuous web product or material, can be inspected for compliance with metrics, such as the quantity and size of holes, pits, cracks, streaks, bugs, blister, bumps, splash, grooves, dirt, bubble, ripple, wrinkle, dents, or any other defect optically visible making it less valuable for the user or customer. Such continuous web products may include paper, metals, plastic foils and non-woven materials whereby the visual quality of these products or product surfaces may be monitored.

Image(s) of the sample-object 14 illuminated by a light source 13 is obtained by an imaging device or camera 16. As shown in FIGURE 1, the

one or more specific vision tools for the second computer to run on the acquired image data. The first computer also sends to the second computer parameters needed by the second computer to run the selected vision software. The second computer runs the selected vision software on the transferred image to obtain a result. The result is sent from the second computer to a designated location.

BRIEF DESCRIPTION OF THE DRAWINGS

The present invention is further described in the detailed description which follows, by reference to the noted drawings by way of non-limiting exemplary embodiments, in which like reference numerals represent similar parts throughout the several views of the drawings, and wherein:

Fig. 1 illustrates an embodiment of the present invention;

Fig. 2 illustrates a prior art machine vision system;

Figs. 3(a) and 3(b) illustrates an embodiment of the invention in which a first computer arrangement is shown;

Fig. 4 illustrates an embodiment of the invention in which a second computer arrangement is shown;

Fig. 5 is a flow diagram explaining the process of a first computer of the present invention; and

Fig. 6 is a flow diagram explaining the process of a second computer of the present invention.

DETAILED DESCRIPTION

Figure 1 is a diagram illustrating an embodiment of a networked machine vision system 100. The illustrated system 100 includes a first computer 102, a second computer

104, and a communications link (an internetwork) 106. In the system of Fig. 1, image data is sent from first computer 102 to remotely located second computer 104 via communications link 106. Vision tool parameters may also be sent, if needed, from first computer 102 to remotely located second computer 104. Second computer 104 analyzes the image data and any vision tool given parameters that may be sent, using an chosen vision tool to produce an given result. The result is sent from second computer 104 to first computer 102 via the communications link 106. The communications link located between the first and second computer may be an Internet connection or wide area network (WAN) connection.

Figure 3 (a) illustrates an arrangement of the first computer 102 in an embodiment of the present invention. First computer 102 includes a collector 302, a transmitter 304, and a receiver 306. Figure 3 (b) further shows collector 302 of Fig. 3(a). Collector 302 includes an image acquirer 308, for example, a frame grabber, client data procurer 310, and selector 312. Collector 302 may uses a protocol such as DCOM (Distributed Component Object Model) or CORBA (Common Object Request Broker Architecture), to provide a standard method for inter-process communication in a heterogeneous environment. DCOM and CORBA are examples of distributed object computing infrastructures which automate many common network programming tasks such as object registration, location, and activation, request demultiplexing, framing and error-handling, parameter marshalling and demarshalling, and operation dispatching. Client data procurer 310 sends an acquisition command 316 to image acquirer 308 to acquire an image 314.

The image acquirer 308 may be stored on first computer 102 or remote from first computer 102 such that image acquirer 308 used to acquire the image data may be local or networked. Software demonstration image data may be stored at second computer 104 or on a computer connected to second computer 104. The source of the image may include a

camera, x-ray, scanning electron microscopes or focused ion beams. Image acquirer 308 responds to the acquisition command 316 by returning an image 314 to client data procurer 310. Next, selector 312 selects a vision operation tool to be used to analyze the image 314. Multiple vision tools may be indicated by selector 312. The selected vision tool may include such vision operations as guidance, inspection, gauging or identification. Most vision operations require additional parameters to precisely specify their behavior, and correspond with the selected vision tool; however, these additional parameters may not be needed in every case. The corresponding parameters for the selected vision tools may include, for example: in a guidance operation, a model pattern and constraints on the alignment operation such as minimum match quality and allowable scale and rotation change; or in a gauging operation the corresponding parameter may include the polarity of an edge transition, the expected angle of the edge, the type of scoring operation to perform or the minimum edge intensity.

Vision tool parameters that correspond to the selected vision tool may be entered manually at the first computer 102, for example, by using a keyboard, mouse, or touchpad in a software demonstration scenario. The vision tool parameters may also be entered, for example in a manufacturing or production environment, using a keyboard, mouse, touchpad, or an application program in collector 302. The acquired image data 314, vision tool parameters (if any), and the selected vision tool are sent by transmitter 304 to second computer 104 to be analyzed using the selected vision tool. The data transmitted by transmitter 304 may also contain information such as client account information or a password. The image data 314 may be transmitted using a format such as JPEG or .bmp file. The receiver 306 is used to receive an analyzed result of the selected vision tool from the second computer 104.

Figure 4 illustrates an arrangement of the second computer 104 in an embodiment of the present invention. Second computer 104 includes a receiver 402, a validator 408, an analyzer 404, and a transmitter 406. Receiver 402 receives the information and data transmitted from the first computer 102. The received information includes acquired image data, corresponding vision tool parameters (if any), the selected vision tool, and client identifiers. Once the information is received on receiver 402, the information and data are verified by validator 408. Validator 408 functions to ensure client account security so that client identifiers such as account information and passwords are verified. The image data and vision tool parameters (if any) may be verified within the selected vision tool or by a validator independent from validator 408. If an incorrect client identifier entry is received, validator 408 will return an error message to first computer 102. Once the received client identifier information is verified by validator 408, analyzer 404 uses the selected vision tool to analyze the acquired image data and any corresponding vision tool parameters. If an invalid image or vision tool parameters have been provided by first computer 102, analyzer 404 will return an error result to first computer 102. Otherwise, if image data and vision tool parameters (if any) are valid, analyzer 404 will perform the selected vision operation to obtain an analyzed result. The analyzed result will be sent by transmitter 406 to a designated location. The designated location may include first computer 102 or a computer other than the first computer 102.

Fig. 5 explains the operation of the first computer in an embodiment of the invention. At P500 first computer 102 acquires image data. The image may be acquired from a location remote from first computer 102 or stored at a location on first computer 102.

At P502 a vision operation tool is selected to analyze the acquired image. The selected vision operation tool is remotely located from the first computer 102 -- in a different

part of the same building (site) at a different site, or in another part of the country (or world). Multiple vision operation tools may be selected to conduct various data analysis.

At P503 vision tool parameters, if any, are entered. The vision operation tools correspond to each vision tool selected at P502.

5 At P504 the acquired image data, selected vision tool(s), corresponding vision tool parameters (if any), and client account information are sent from first computer 102 to second computer 104 via a communications link 106.

At P514 an analyzed result or error message is received from second computer 104. The analyzed result or error message is obtained from the processing of the acquired image data and any corresponding vision tool parameters using the selected vision operation tool.

10 Fig. 6 explains the operation of the second computer in an embodiment of the invention. At P600 acquired image data, a selected vision tool, vision tool parameters (if any), and client account information are received from first computer 102.

At P602 the client account information received at P600 is validated. The validation maintains client account security by verifying that a correct client identifier and password have been entered. If any information fails to be validated, an error message is sent to the first computer 102.

At P604 the image data, vision tool and any vision tool parameters are verified to ensure that the correct type, number and values required for the selected vision tool have been entered.

At P606 the acquired image data and any vision tool parameters are processed using the selected vision tool to produce an analyzed result.

At P610 the analyzed result is sent from the second computer 104 to a designated location via a communications link. The designated location may include the first computer

102 or a location other than the first computer 102. The communications link 106, as discussed above, may include an Internet connection or a wide area network (WAN) connection.

If more than one vision tool is selected, the second computer 104 may execute P604, P606 and P610 in turn for each selected vision tool.

The present invention may be implemented by hardware or by a combination of hardware and software. The software may be recorded on a medium and executed by a computer. The medium may be, but is not limited to, for example, a floppy disk, a CD ROM, a writable CD, a Read-Only-Memory (ROM), or an Electrically Erasable Programmable Read Only Memory (EEPROM).

While the invention has been described with reference to certain illustrated embodiments, the words that have been used herein are words of description, rather than words of limitation. Changes may be made, within the purview of the appended claims, without departing from the scope and spirit of the invention in its aspects. Although the invention has been described herein with reference to particular structures, acts, and materials, the invention is not limited to the particulars disclosed, but rather extends to all equivalent structures, acts, and materials, such as are within the scope of the appended claims.